MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

EEE 7276 – DESIGN OF ON AND OFF GRID PV SYSTEMS

18 MARCH 2017
9:00 AM – 12:00 PM
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 3 pages including the cover page with 5 Questions only.
2. Answer ALL questions. The distributions of marks for each question are as stated.
3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) Define the following terms related to Sun Resource.

(i) Solar constant [2 marks]

(ii) Peak Sun Hour (PSH) [2 marks]

(iii) Air mass factor [2 marks]

(iv) Altitude angle [2 marks]

(v) Azimuth angle [2 marks]

(b) Find the position of the sun (compute α and ψ) at a place whose latitude and longitudes are 47.6° N and 122.4° W, respectively on July 1 at 2:00 p.m. Neglect correction due to equation of time. Take $\lambda_{std} = 120°$ for the place. (Hint: $\sin\alpha = \sin\delta \sin\varphi + \cos\delta \cos\varphi \cos\omega$ and $\cos\psi = \frac{\sin\alpha \sin\varphi - \sin\delta}{\cos\alpha \cos\varphi}$) [10 marks]

Question 2

(a) Sketch four different circuit models of a PV cell and write down the current equation for each model. [10 marks]

(b) Calculate the maximum power, cell efficiency and fill factor of a solar cell at the intensity of 200 W/m^2 given $V_{OC} = 0.24$ V; $I_{SC} = 9$ mA; $V_{MP} = 0.14$ V; $I_{MP} = 6$ mA; Area of the cell = 4 cm^2 [5 marks]

(c) Discuss briefly mismatch effects in Solar Cells/Modules. [5 marks]

Question 3

(a) Sketch a typical grid connected PV system and mark all the important components. [8 marks]

(b) Design a PV array configuration for a 15 kW system using the following information and taking the temperature variation into account. [12 marks]

Ratings of PV module:
Power rating = 305 Wp
$V_{OC} = 64.2$; $I_{SC} = 5.96$ A; $V_{MP} = 54.7$ V; $I_{MP} = 5.58$ A
Ambient temp = 25°C
Module operation temperature varies from -30°C to +62°C
Inverter rating:
$V_{OC, max} = 600$ V; 250 V < V_{MP} < 480 V;
$I_{inverter, max} = 30$ A;
Output AC voltage adjustable from 208 V – 277 V

Continued...

Question 4

(a) A 1-kW AC load for 8 h per day has to be supplied by a stand-alone PV system. The battery voltage of the system is 36 V and the battery trip efficiency is 80%. The inverter efficiency is 95%. The PSH at the place is 3.6. Calculate the number of PV panels required, if one panel rating is 130 Wp and the nominal voltage is 14 V. Also decide about the configuration of PV panels. [9 marks]

(b) Draw a block diagram of a simple stand-alone PV system with AC and DC loads. [5 marks]

(c) What are the requirements of a stand-alone inverter in a stand-alone PV system? [6 marks]

Question 5

(a) Distinguish between the following types of PV mountings.
- (i) Fixed-tilt array mounting
- (ii) Adjustable-tilt array mounting
- (iii) Sun tracking array mounting

[6 marks]

(b) The cost of various components of a PV system is given in the table below.

Item	PV	Battery	Charger	Inverter	Installation cost	M&O/year
Cost	\$5/Wp	\$1.705/Ah	\$5.878/A	\$0.831/W	10% of PV cost	2% of PV cost

Peak power of the panel is 23.2 Wp and the number of panels in the system is 60. Battery capacity = 1500 Ah. Charger rating is 50 A and inverter rating is 1020 W. The lifetime N of all the items is considered to be 20 years, except that of the battery which is considered to be 5 years. Thus, an extra 3 groups of batteries have to be purchased, after 5 years, 10 years, and 15 years. Assume an inflation rate i of 3% and an interest rate r of 10%. Compute the life cycle cost (LCC) of the system. [14 marks]

(Hint: The present worth (PW) of a payment S to be made after N years is

$$\frac{S(1+i)^N}{(1+r)^N}$$

The present worth of a uniform annual series of payments q after N years

$$C_{MPW} = q \times x \times \left(\frac{1-x^N}{1-x}\right) \text{where } x = \left(\frac{1+i}{1+d}\right)$$)

End of Paper